Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, DC 20554

In the Matter of	)	
	)	
Amendment of Part 90 of the Commission's Rules	)	WP Docket No. 07-100
	)	
Implementing a Nationwide, Broadband, Interoperable Public Safety Network in the 700 MHz Band	)	PS Docket No. 06-229
	)	
Service Rules for the 698-746, 747-762 and 777-792 MHz Bands	)	WT Docket No. 06-150

COMMENTS OF THE
NATIONAL ACADEMY OF SCIENCES'
COMMITTEE ON RADIO FREQUENCIES

The National Academy of Sciences, through the National Research Council's Committee on Radio Frequencies (hereinafter, CORF), hereby submits its Comments in response to the Commission's Fifth Further Notice of Proposed Rulemaking (FCC 12-61) in the above-captioned dockets (FFNPRM). In these Comments, CORF discusses the proposed new rules for aeronautical mobile use of spectrum at 4940-4990 MHz (4.9 GHz band) and the potential interference impact on Radio Astronomy Service (RAS) observations in that band. CORF recognizes that communications technologies are critical to maintaining and improving public safety, and CORF has long supported the thoughtful sharing of spectrum among services, when such sharing is practical. However, as recognized in footnotes to the FCC's Table of Allocations, an aeronautical service transmitting down to Earth is the worst-case scenario in regard to potential interference problems for RAS facilities. Nevertheless, CORF does not oppose lifting the general prohibition on aeronautical use of the 4.9 GHz band, as long as the Commission enacts all of the proposed protections for the RAS in the FFNPRM, that is, that any new rules for aeronautical use in this band should (1) make the aeronautical use secondary to terrestrial services, including the RAS; (2) limit the altitude of use of this band to 1,500 feet above the altitude of the observatory and limit operation to greater than 50 miles from observatories operating at this frequency or otherwise prevent line-of-sight transmissions to RAS facilities; (3) require applicants to demonstrate that the proposed aeronautical use will protect from interference RAS observatories within the threshold distance from the edge of aeronautical operations; and (4) require applicants to certify that they have served a copy of their application to any RAS observatories within that threshold distance.

I. Introduction: The Role of Radio Astronomy, and the Unique Vulnerability of Passive Services to Interference.

CORF has a substantial interest in this proceeding, because it represents the interests of the passive scientific users of the radio spectrum, including users of the RAS bands. RAS observers perform extremely important yet vulnerable research.

As the Commission has long recognized, radio astronomy is a vitally important tool used by scientists to study our universe. It was through the use of radio astronomy that scientists discovered the first planets outside the solar system, circling a distant pulsar. It has also enabled the discovery of organic matter and prebiotic molecules outside our solar system, leading to new insights into the potential existence of life elsewhere in our galaxy. Measurements of radio spectral line emission have identified and characterized the birth sites of stars in our own galaxy, the processes by which stars slowly die, and the complex distribution and evolution of galaxies in the universe. Radio astronomy measurements discovered the cosmic microwave background (CMB). Left over from the original big bang, this radiation has cooled to only 2.7 degrees above absolute zero but still carries the imprint of the distribution of matter and energy from the very early universe. The discovery and analysis of the CMB have been recognized by three Nobel prizes in physics and constitute one of the most active areas of research in modern astrophysics. Later observations discovered the weak fluctuations in the CMB of only one-thousandth of a percent, generated in the early universe, which later formed the stars and galaxies we know today. Radio observations uncovered the first evidence for the existence of a black hole in our galactic center, a phenomenon that may be crucial to galaxy formation. Observations of supernovae have allowed us to witness the distribution of heavy elements essential to the formation of planets like Earth, and of life itself.

However, the critical science undertaken by RAS observers cannot be performed without access to interference-free spectrum. Notably, the emissions that radio astronomers receive are extremely weak—a radio telescope receives less than 1 percent of one-billionth of one-billionth of a watt (10^{-20} W) from a typical cosmic object. Because radio astronomy receivers are designed to pick up such remarkably weak signals, radio observatories are particularly vulnerable to interference from in-band emissions, spurious and out-of-band emissions from licensed and unlicensed users of neighboring bands, and emissions that produce harmonic signals in the RAS bands. Even weak, distant in-band man-made emissions can preclude RAS use.

In sum, the important science performed by radio astronomers cannot be performed without access to interference-free spectrum. Loss of such access constitutes a loss for the scientific and cultural heritage of all people, as well as a loss of the practical applications from the information learned and the technologies developed.

Of particular concern in this proceeding is protection of RAS observations in the 4.9 GHz band. Radio astronomy observations in the 4.9 GHz band are extremely useful in studying the brightness distributions of objects such as ionized hydrogen clouds surrounding young stars, remnants of supernovae which mark the cataclysmic end of stars, and ejecta traveling at nearly the speed of light from black holes in the nuclei of galaxies. Such observations allow scientists to construct detailed maps of such phenomena, to understand their structures and dynamics, and to derive physical parameters from the sources, such as their total masses. Observations of radio emissions from neutron stars and black holes are particularly sensitive to interference due to variability, and one cannot just re-observe such phenomena at a later time. The current benefits of this scientific research, obtained through years of work and substantial federal investment, as well as future benefits, must be protected.

In recognition of the importance of the radio astronomy research done in the 4.9 GHz band, Footnote US385 states that "[i]n the bands . . . 4950-4990 MHz, every practicable effort will be made to avoid the assignment of frequencies to stations in the fixed and mobile services that could interfere with radio astronomy observations" at certain RAS observatories listed therein, and further states that "every practicable effort will be made to avoid assignment of frequencies in these bands to stations in the aeronautical mobile service which operate outside of those geographic areas, but which may cause harmful interference to the listed observatories." Similarly, Footnote US342 states that "all practicable steps shall be taken to protect the radio astronomy service" at 4950-4990 MHz, and also states that "[e]missions from spaceborne or airborne stations can be particularly serious sources of interference to the radio astronomy service . . . ." Footnote US342 does not limit that protection to only the RAS observatories listed in Footnote US385.[1]

II. CORF Does Not Oppose Lifting the General Prohibition on Aeronautical Use of the 4.9 GHz band for Public Safety, If Such Use Is Subject to All of the Proposed Protections for the RAS, Including Secondary Status for Aeronautical Use.

CORF recognizes that communications technologies are critical to maintaining and improving public safety, and it is generally in the public interest for the Commission to improve the ways that communications technologies are used toward that goal. Similarly, CORF has long supported the thoughtful sharing of spectrum among services, when such sharing is practical.

The proposed widespread and regular aeronautical use of the 4.9 GHz band, however, raises significant risks of interference to RAS facilities. While terrestrial services are quite capable of causing interference to sensitive RAS facilities, aeronautical uses are even more capable of such effects, due to the breadth of the geography "seen" by an airborne transmitter, and the ease with which such transmissions can be made directly into the main lobe of the RAS receiver.[2] As noted in 2003 in paragraph 60 of the FFNPRM, "the Commission concluded that it could not fashion a general rule to permit aeronautical mobile operation that would adequately

[1] Protection of the RAS should apply to the observatories listed in Appendix B, attached hereto.

[2] See Footnote US342.

protect radio astronomy from interference in all scenarios." It is unclear what has changed in the intervening time.

It is important to recognize that given the sensitivity of RAS receivers, once transmissions at 4.9 GHz (even at Section 90.1215 "low-power" levels) are in the line of sight of an RAS receiver, the interference far exceeds acceptable levels, regardless of distance separation and regardless of where that RAS antenna is pointed. Based on Recommendation ITU-R RA.769-2, at 4.9 GHz the level of interference detrimental to radio astronomy is -241 dB(W/m^2/Hz). Accordingly, a low-power 4.9 GHz transmitter would have to be about 15,650 miles away from the RAS receiver,[3] or about four times the radius of Earth, to comply with the requirements of Recommendation 769. Thus, preventing line-of-sight transmission is critical to any practical sharing of the 4.9 GHz band with aeronautical mobile uses.

The line-of-sight issue is triggered when aircraft fly above the horizon of an RAS observatory. This is a function of flight altitude, but also of local geography and the presence or absence of terrain shielding mountains. Assuming a spherical Earth however, then to be below the horizon of the observatory an aircraft with a transmitter must fly below an altitude of $h' = R_e$*(1/cos(d_s/R_e)-1) where:

h' = altitude of the aircraft with a transmitter above the elevation of the observatory,

d_s = surface distance between the aircraft with a transmitter and the observatory, and

R_e = 3,963 miles, the radius of Earth.

This relationship is shown in Figure 1.

[3] Per the proposal, the emitted power for the low-power transmitter is P_T = 8 dBm/MHz or 6.3×10^{-9} W/Hz. The power density at a distant receiver is $P_T/(4\pi R^2)$. For this value to be less than that specified in Rec. 769, $S_{769} = 7.9\times10^{-25}$ W/m^2/Hz, the distance (R) should be greater than R > $\sqrt{(P_T/4\pi S_{769})}$ or R > 15,653 miles.

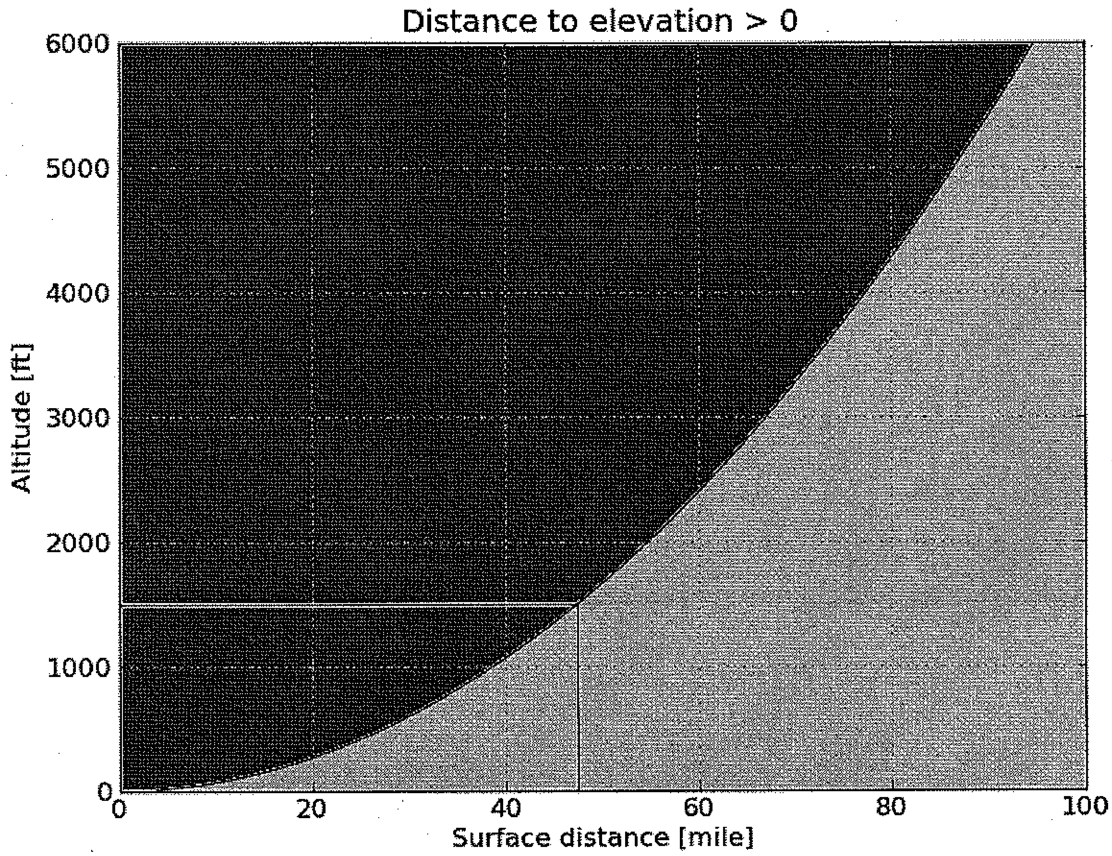

Figure 1: Distance-altitude relationship indicating when an airborne transmitter is within the line of sight of an observatory, assuming no terrain blocking. The red area is above the line-of-sight threshold.

The FFNPRM seeks comments on whether a maximum altitude of 1,500 feet above the altitude of the observatory should be enacted. CORF supports that proposal as a simple method for minimizing line-of-sight transmissions into RAS facilities provided that operation is prohibited within 50 miles of an observatory.[4] Such a prohibition limits the risk that applicants would propose use only up to a certain locationally dependent altitude, but once authorized, fly and transmit from a greater altitude, and it limits the

[4] Note that transmission at an altitude of 1,500 feet corresponds to transmission at a distance of 47.5 miles, and so using 50 miles is consistent with appropriate protection for RAS facilities.

risk associated with disagreements over the effectiveness of terrain blocking features in a particular scenario.

Other protections proposed in paragraph 61 of the FFNPRM are equally important to protecting the RAS, if authorization of aeronautical use of the 4.9 GHz band without use of the waiver process is to be permitted.[5]

First, the Commission should require an applicant to provide a description demonstrating that aeronautical mobile operations will protect radio astronomy observations from interference. Such descriptions would assist the Commission in conducting its evaluation of the interference potential of an application. Further, a requirement to demonstrate non-interference to other users is common in wireless service applications, and accordingly, cannot be considered unusually burdensome. Such demonstrations are typically performed by frequency coordinators in other Part 90 public safety radio services, and the same could apply in the case of this service.

Second, applicants should also be required to certify to the Commission that they have served a copy of the application to all listed radio astronomy observatories whose boundaries fall within a threshold distance[6] from the edge of the aeronautical operation. While applicants may in good faith believe that they have properly demonstrated that their proposed use will not interfere with RAS facilities, often the technical staff of such

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[5] It is noted that the ITU Radio Regulations allocate this band to the EESS and space research science (SRS) on a secondary basis, and the use of this service near an international border should be examined in that light.

[6] The "threshold distance" would be 50 miles, if the Commission enacts its proposed prohibition on aeronautical use of the frequency at altitudes greater than 1,500 feet above the altitude of the observatory. Otherwise, the distance would be that set forth in Figure 1. Notifications to RAS observatories should be made through the Electromagnetic Spectrum Management Unit, Division of Astronomical Sciences, National Science Foundation. E-mail notification is preferred, to esm@nsf.gov. The mailing address of the NSF is 4201 Wilson Blvd., Arlington, VA 22230.

an RAS facility has more experience in the unique task of evaluating potential interference to that facility, and thus can perform a critical back-up role in the process. Serving a copy of applications to potentially affected RAS observatories has precedent in the Commission's rules,[7] and the electronic transmission of an application to a listed observatory adds little, if any, extra burden to the application process.

Third, even with the protections described above and in paragraph 61 of the FFNPRM, aeronautical use of the 4.9 GHz band should be on a secondary, non-interference basis. The premise of the FFNPRM is that aeronautical use should not be allowed to interfere with RAS (and other terrestrial) use. It is hoped that the proposed protections, if enacted, will achieve that result. But even with the proposed protections to prevent predicted interference, there are many variables in operational use involving altitude and terrain shielding that could result in actual interference to terrestrial services. In such cases, the option of demanding non-interference must be present, which would be the case if the aeronautical service had a secondary allocation status.[8]

III. Conclusion.

CORF recognizes that communications technologies are critical to maintaining and improving public safety, and CORF has long supported the thoughtful sharing of

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[7] See, Section 1.924(a)(1) of the Commission's rules.

[8] Secondary status would be even more critical if the proposed protections are not enacted. In any case, radio astronomers are good citizens and would be unlikely to object to interference resulting from aeronautical use during and immediately following a natural disaster, or other critical emergency. Of greater concern would be interference resulting from routine testing of aeronautical facilities, or use in non-emergency situations. For example, aeronautical use of the 4.9 GHz band for ongoing surveillance should not be a basis for avoiding the protections proposed in the FFNPRM and causing interference to RAS facilities. Similarly, testing of aeronautical facilities transmitting in the 4.9 GHz band should be subject to all of the proposed RAS protections. In any case, CORF advocates cooperation in the implementation and testing of aeronautical facilities in this band.

spectrum among services, when such sharing is practical. The proposed widespread and regular aeronautical use of the 4.9 GHz band, however, raises significant risks of interference to RAS facilities, as recognized in previous Orders in this proceeding, as well as in footnotes to the Table of Allocations. CORF does not oppose lifting the general prohibition on aeronautical use of the 4.9 GHz band, as long as the Commission enacts all of the proposed protections for the RAS in the FFNPRM, that is, that any new rules for aeronautical use in this band should (1) make the aeronautical use secondary to terrestrial services, including the RAS; (2) limit the altitude of use of this band to 1,500 feet above the altitude of the observatory and limit operation to greater than 50 miles from observatories operating at this frequency or otherwise prevent line-of-sight transmissions to RAS facilities; (3) require applicants to demonstrate that the proposed aeronautical use will protect from interference RAS observatories within the threshold distance from the edge of aeronautical operations; and (4) require applicants to certify that they have served a copy of their application to any RAS observatories within that threshold distance.

Respectfully submitted,

NATIONAL ACADEMY OF SCIENCES'
COMMITTEE ON RADIO FREQUENCIES

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Appendix A

Committee on Radio Frequencies

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Consultants

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Appendix B

Protection of RAS should apply to the following observatories:

Observatory	Observatory Coordinates		Observatory Altitude (ft)
Allen Telescope Array, Hat Creek, CA	Rectangle between latitudes 40° 00' N and 42° 00' N and between longitudes 120° 15' W and 122° 15' W.		3,353
NASA Goldstone Deep Space Communications Complex, Goldstone, CA	80 kilometer (50 mile) radius centered on 35° 20' N, 116° 53' W.		2,451
National Astronomy and Ionosphere Center, Arecibo, PR	Rectangle between latitudes 17° 30' N and 19° 00' N and between longitudes 65° 10' W and 68° 00' W.		1,631
National Radio Astronomy Observatory, Socorro, NM	Rectangle between latitudes 32° 30' N and 35° 30' N and between longitudes 106° 00' W and 109° 00' W.		6,939
National Radio Astronomy Observatory, Green Bank, WV	Rectangle between latitudes 37° 30' N and 39° 15' N and between longitudes 78° 30' W and 80° 30' W.		2,648
National Radio Astronomy Observatory, Very Long Baseline Array Stations	80 kilometer radius centered on:		(see below)
	North latitude	West longitude	
Brewster, WA	48° 08'	119° 41'	820
Fort Davis, TX	30° 38'	103° 57'	5,269
Hancock, NH	42° 56'	71° 59'	971
Kitt Peak, AZ	31° 57'	111° 37'	6,240
Los Alamos, NM	35° 47'	106° 15'	6,437
Mauna Kea, HI	19° 48'	155° 27'	12,346
North Liberty, IA	41° 46'	91° 34'	728
Owens Valley, CA	37° 14'	118° 17'	3,924
Pie Town, NM	34° 18'	108° 07'	7,759
Saint Croix, VI	17° 45'	64° 35'	52
Owens Valley Radio Observatory, Big Pine, CA	Two contiguous rectangles, one between latitudes 36° 00' N and 37° 00' N and between longitudes 117° 40' W and 118° 30' W and the second between latitudes 37° 00' N and 38° 00' N and between longitudes 118° 00' W and 118° 50' W.		4,009